



Understanding DPR DSD Parameters on a Global Scale

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I. INTRODUCTION

The Global Precipitation Measurement (GPM) core satellite carries the first spaceborne dual-frequency precipitation radar (DPR) at Ka (35.5 GHz) and Ku (13.6 GHz) frequencies. One of the advancements is that it quantitatively estimates the precipitation particle size distributions. The estimated size parameter, often called the "mass weighted mean diameter", D_m , offers new physical insights into microphysical properties of precipitation around the globe.

The Level-3 DPR product provides gridded precipitation quantities and statistics based on the Level-2 swath data. We use 4 years of DPR L-3 data with 5° grid resolution to quantify the horizontal and vertical distribution of D_m , along with the corresponding N_w and precipitation rates. We also investigate its seasonal variations and relationships with surface and rain types.

II. ANNUAL MEAN OF PRECIPITATION SIZE, NUMBER, AND RATE

Based on Seto et al. (2013) and Williams et al. (2014), the drop size distribution (DSD) in the DPR algorithm uses a normalized gamma distribution function, where the number density is:

$$N(D) = N_w f(D; D_m), \quad N_w = \frac{4^4}{\pi \rho_w} \left(\frac{q}{D_m^3} \right) \quad \text{and} \quad D_m = \frac{\sum_{D_{min}}^{D_{max}} D^4 dD}{\sum_{D_{min}}^{D_{max}} D^3 dD}$$

The precipitation rate is:

$$R = N_w H(D_m), \quad \text{where} \quad H(D_m) = 0.6\pi \times 10^{-3} \int_{D=0}^{\infty} V(D) D^3 f(D; D_m) dD$$

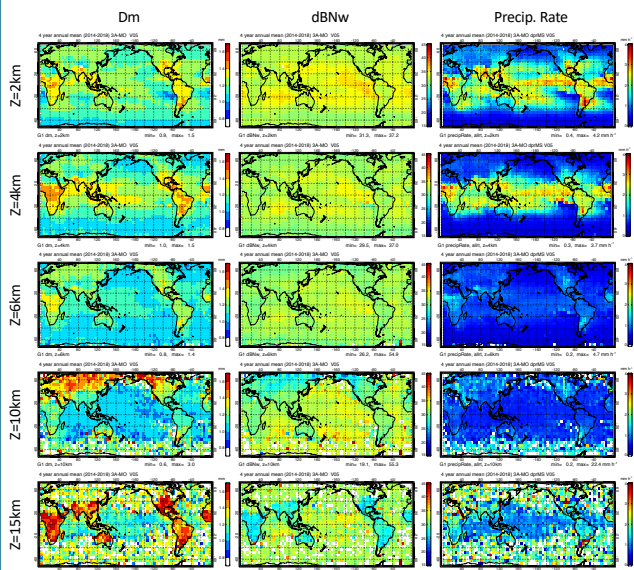
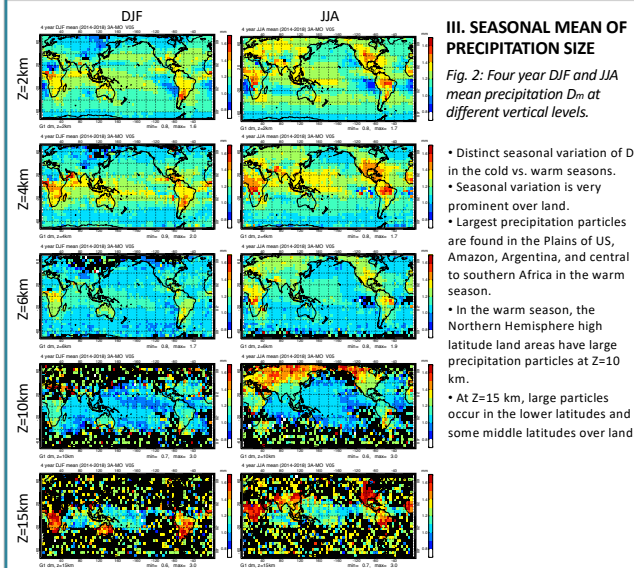


Fig. 1: Four year annual mean DSD parameters and precipitation rate at different vertical levels.

- D_m is larger over land than over the ocean.
- Shallow cumulus regions in the eastern side of ocean basins have smaller particle sizes than the western ocean basins.
- Arid and desert regions over land have small particle sizes.
- In the middle to high latitudes of Eurasian and North America, the particle sizes are large at Z=10 km.
- At Z=15 km, large particles are present in the lower latitudes over land.

Seto, S., T. Iguchi, and T. Oki. 2013. The basic performance of a precipitation retrieval algorithm for the Global Precipitation Measurement Mission's single/dual-frequency radar measurements. *IEEE Trans. Geosci. Remote Sens.*, 51, 5239–5255, doi:10.1109/TGRS.2012.2231686.

Williams, C. R., and Coauthors. 2014. Describing the shape of raindrop size distributions using uncorrelated raindrop mass spectrum parameters. *J. Appl. Meteor. Climatol.*, 53, 1282–1296, doi:10.1175/JAMC-D-13-076.1.



III. SEASONAL MEAN OF PRECIPITATION SIZE

Fig. 2: Four year DJF and JJA mean precipitation D_m at different vertical levels.

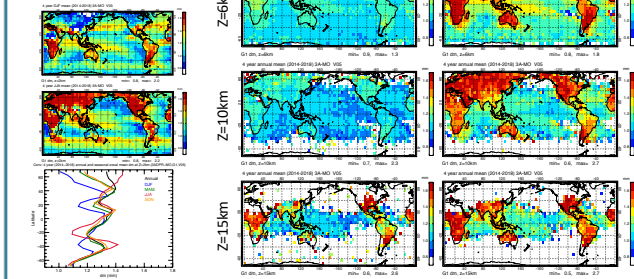
- Distinct seasonal variation of D_m in the cold vs. warm seasons.
- Seasonal variation is very prominent over land.
- Largest precipitation particles are found in the Plains of US, Amazon, Argentina, and central to southern Africa in the warm season.
- In the warm season, the Northern Hemisphere high latitude land areas have large precipitation particles at Z=10 km.
- At Z=15 km, large particles occur in the lower latitudes and some middle latitudes over land.

IV. STRATIFORM VS CONVECTIVE D_m

Fig. 3 (right): Strat. vs conv. D_m at different altitudes

- Convective precipitation has larger D_m at all levels.
- Large- D_m convection is prominent over land.
- Large particles occur at Z=15 km for stratiform.

Fig. 4 (below): Example of DJF vs JJA convective D_m and its annual and seasonal zonal mean



V. CONVECTIVE FRACTION

The fraction of convective precipitation is calculated to help us understand the characteristics of D_m shown in the previous figures. Generally, the detection of a bright band determines stratiform rain.

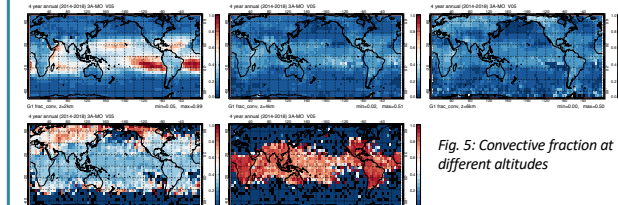
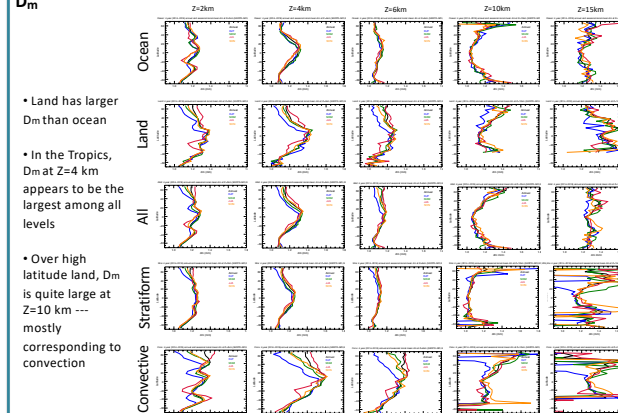


Fig. 5: Convective fraction at different altitudes

- Over the ocean, lower latitudes have high convective fraction. Eastern oceans may correspond to warm rain.
- At Z=10 km, high convective fraction in the Northern Hemisphere high latitudes corresponds to large D_m .
- At Z=15 km, high convective fraction may indicate that only deep convection can reach such high altitudes.

VI. ZONAL MEAN D_m

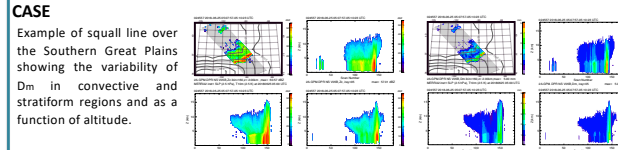
Fig. 6: Zonal mean D_m (2014–2018) at different altitudes for ocean vs land, all samples (3° row), and stratiform vs convective



- Land has larger D_m than ocean
- In the Tropics, D_m at Z=4 km appears to be the largest among all levels
- Over high latitude land, D_m is quite large at Z=10 km --- mostly corresponding to convection

VII. A SQUALL LINE CASE

Fig. 7: Horizontal and vertical views of Ku NS reflectivity (left) and D_m (right)



VIII. SUMMARY

We analyzed four years of GPM DPR data to study precipitation particles sizes over the globe. Particle size distributions show clear contrasts over land vs. ocean, with distinct variations as a function of season, latitude, and altitude. Large particles are generally associated with convective precipitation, except for warm rain regions over the low latitudes of eastern ocean basins. Large particles are found in northern Eurasia and North America at high altitudes in the warm season, which corresponds to large convective fractions reaching that level. The particle sizes of stratiform precipitation at Z=15 km are large, which will be further investigated. Individual cases are being selected to improve the understanding of the statistics of D_m .